TOWARDS CONSCIOUS STOCHASTIC SYSTEMS

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A modeling procedure for enhancing performance of stochastic systems is proposed.

A natural, but expensive, approach to enhance performance of systems is to construct a hierarchy of observations and control. On the first level of this hierarchy systems perform certain functions in response to external (sensory) input. On the second level systems have ability to observe their performance and to make corrections, if necessary, according to certain criteria. On the third level systems have ability to observe the second level procedures of observation-control and correct them. Presently the cost of the third and higher level artificial systems seems prohibitive. However, theoretically, we can imagine a limit in this hierarchy and can call the resulting systems conscious.

Hierarchical structures appear naturally in systems with strong interaction of many degrees of freedom. Typical signatures of such hierarchy are so-called similarity laws. Particularly, in turbulence the concept of scale-similarity was developed and was associated with the infinitely-divisible distributions [1]. The activity of the human brain also revealed the regime of scale-similarity, which was discovered by using the multi-channel MEG (magnetoencephalogram) [2,3] and EEG (electroencephalogram)[4]. Hundreds of billions of interconnected neurons and surrounding sells (particularly, astroglia), apparently, is favorable playground for hierarchical structures in the brain.

The electrochemical brain activity is taking place in wet and warm surroundings. To reproduce such activity in artificial systems, even approximately, seems impossible. However, modeling of the effects of consciousness [5-9] can be used to enhance performance of systems.

Consider first level system represented by equations:

$$\frac{dx_k}{dt} = f_k(\mathbf{x}, \mathbf{s}), \; k = 1, ..., n \tag{1}$$

Here $\mathbf{x}(t) = (x_1, ..., x_n)$ are variables of reaction to the sensory input $\mathbf{s}(t) = (s_1, ..., s_m)$, f_k are some functions. Sensory input $\mathbf{s}(t)$, generally, is m-dimensional stochastic process with mean values $< \mathbf{s}(t) >$ and fluctuations $\mathbf{s}'(t) = \mathbf{s}(t) - < \mathbf{s}(t) >$. Certain probability distribution is assumed for fluctuations of sensory input. It could be Gaussian or some empirically found distribution.

Now, in accord with [5-9], we introduce complex variables $\mathbf{z} = \mathbf{x} + \mathbf{i}\mathbf{y}$, where $\mathbf{y} = (y_1, ..., y_n)$ are internal variables representing the effects of consciousness. Substitution of $\mathbf{z}$ instead of $\mathbf{x}$ into (1) gives:

$$\frac{dx_k}{dt} = \mathrm{Re}\{f_k(\mathbf{x} + \mathbf{i}\mathbf{y}, \mathbf{s})\} \tag{2}$$

$$\frac{dy_k}{dt} = \mathrm{Im}\{f_k(\mathbf{x} + \mathbf{i}\mathbf{y}, \mathbf{s})\} \tag{3}$$

Equations (2) and (3) are coupled, assuming that at least some of functions f_k are nonlinear relative to $\mathbf{x}$. Initial values $y_k(0)$ can play a role of adjustable parameters (see below). The effect of such procedure, naturally, depends on functions f_k. If all these functions are linear relative to $\mathbf{x}$, there will be no effect: equation (2) will be reduced to (1) and equation (3) will be irrelevant to the performance of system. Nonlinearity is essential to this approach (in Ref. 5-9 nonlinearity is determined by the sigmoidal firing rate of neurons). In more general procedure quaternions can be used instead of complex variables. In Ref. 6-9 imaginary components of the quaternion correspond to subjective experiences divided in three groups: sensations, emotions and reflections.

Equations (2-3) and analogous quaternion equation can be considered as an stochastic attractor of high level system. It will be interesting in future to prove corresponding theorem with certain restriction on observation-control and on $(\mathbf{f}, \mathbf{s})$. Initial values $\mathbf{y}(0)$ play a role of genetic parameters. In some areas of these parameters the system (with a given statistics of $\mathbf{s}$) may perform better then in others, in some it may not work at all.

Note, that complex fields have been used recently [10] to eliminate classical electromagnetic divergencies, namely, the infinite self-energy of electrons and the paradoxical self-acceleration. The same (algebraic) approach works for the quantum interaction of charges. Possible connection may exist between these fields and fields in the modeling of the effect of consciousness on the electric currents in the human brain [5-9]. Even more general connection is suspected in the context of a new type of quantum cosmology (no "strings" attached) [11-14]. In new interpretation of quantum theory [15] imaginary trajectories and corresponding impulses play an important role.

These connections are in accord with the tendency of Nature to use the same trick in many circumstances. It seems natural to use this trick to enhance performance of stochastic systems.

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